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# NASA TECHNICAL MEMORANDUM



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ARTICLES, PAPERS, AND PRESENTATIONS**

Compiled by Sarah S. Thacker  
Management Services Office

October 1981

**NASA**

*George C. Marshall Space Flight Center  
Marshall Space Flight Center, Alabama*

## **FOREWORD**

In accordance with the NASA Space Act of 1958 the MSFC has provided for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof.

Since July 1, 1960, when the George C. Marshall Space Flight Center was organized, the reporting of scientific and engineering information has been considered a prime responsibility of the Center. Our credo has been that "research and development work is valuable, but only if its results can be communicated and made understandable to others."

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**GEORGE C. MARSHALL SPACE FLIGHT CENTER**  
**Marshall Space Flight Center, Alabama**

**FY 1981 SCIENTIFIC AND TECHNICAL REPORTS,  
ARTICLES, PAPERS, AND PRESENTATIONS**

**TABLE OF CONTENTS**

	<b>Page</b>
<b>NASA TECHNICAL MEMORANDA .....</b>	<b>1</b>
<b>NASA TECHNICAL PAPERS.....</b>	<b>21</b>
<b>NASA REFERENCE PUBLICATIONS.....</b>	<b>24</b>
<b>MSFC CONFERENCE PUBLICATIONS.....</b>	<b>25</b>
<b>NASA CONTRACTOR REPORTS .....</b>	<b>26</b>
<b>MSFC PAPERS CLEARED FOR PRESENTATION.....</b>	<b>50</b>

# NASA TECHNICAL MEMORANDA

**TM-78300** May 1979  
**Thermal Control of High Energy Nuclear Waste, Space Option.** Jerry A. Peoples.  
Preliminary Design Office. N79-25869

A discussion is presented which relates to the thermal and packaging problems of space disposal of nuclear waste material. An approach is suggested which solves both of these problems with emphasis on high energy density waste material. A passive cooling concept is presented utilizing conduction rods which penetrate the inner core. Data are presented which illustrate the effectiveness of cooling rods and the limit of their capability. A computerized thermal model is discussed and developed for the cooling concept.

**TM-78301** June 1979  
**The Space Telescope Observatory.** John N. Bahcall and C. R. O'Dell. Institute for Advanced Study and MSFC.  
N79-27043

This review provides a convenient guide to the expected characteristics of the Space Telescope Observatory for astronomers and physicists. We have tried to provide enough detail so that a professional scientist, observer or theorist, can plan how the observatory may be used to further his observing program or to test theoretical models. Further detail is available in NASA documents that are referenced throughout this report.

**TM-78302** June 1978  
**SCATS — SRB Cost Accounting and Tracking System Handbook.** Ross B. Zorn, Rodney D. Stewart, Gary Coley, and Marie Higginbotham. Systems Analysis and Integration Laboratory and Computer Services Office. N79-27002

This technical memorandum describes the Solid Rocket Booster Cost Accounting and Tracking System (SCATS) which is an automatic data processing system designed

to keep a running account of the number, description, and estimated cost of Level II, III, and IV changes. Although designed specifically for the Space Shuttle Solid Rocket Booster Program, the ADP system can be used for any other program that has a similar structure for recording, reporting, and summing numbers and costs of changes. The program stores the alpha-numeric designators for changes, government estimated costs, proposed costs, and negotiated value in a MIRADS (Marshall Information Retrieval and Display System) format which permits rapid access, manipulation, and reporting of current change status. Output reports listing all changes, totals of each level, and totals of all levels, can be derived for any calendar interval period.

**TM-78303** June 1979  
**Apollo Telescope Mount — A Partial Listing of Scientific Publications and Presentations, Supplement 3.** Edited by John M. Reynolds, Stanley A. Fields, and William C. Snoddy. Space Sciences Laboratory.  
N79-27500

This report supplements NASA TM X-73300, NASA TM X-73393, and NASA TM-78183. These reports are compilations of bibliographies from the principal investigator groups of the Apollo Telescope Mount (Skylab solar observatory facility) that gathered data from May 28, 1973, to February 8, 1974. The analysis of these data is presently under way and is expected to continue for several years.

The publications listed in this report are divided into the following categories: (1) Journal Publications, (2) Journal Publications Submitted, (3) Other Publications, (4) Presentations — National and International Meetings, and (5) Other Presentations. An author index is included together with errata for previous reports.

## NASA TECHNICAL MEMORANDA

TM-78304

July 1980

Self-Replicating Systems - A Systems Engineering Approach. Georg von Tiesenhausen and Wesley A. Darbro. Program Development and Space Sciences Laboratory. N80-34209

This study develops a first approach to conceptualize self-replicating systems from past and present abstract theories. The engineering elements of Self-Replicating Systems are defined in terms of a basic reference system. A number of options are investigated. The growth characteristics and their problems are analyzed, the mathematics of various exponential growth options are outlined, and the problems of universal parts production and systems closure are discussed. Selected areas of further study are defined and a 20-year development and demonstration program is presented.

TM-78305

August 1980

Characterization of Three Types of Silicon Solar Cells for SEPS Deep Space Missions. A. F. Whitaker, S. A. Little, V. A. Wooden, D. E. Carter, B. E. Cothren, and C. A. Torstenson. Materials and Processes Laboratory. N80-33863

Three types of high performance silicon solar cells, sculptured BSR/P<sup>+</sup> (K7), BSR/P<sup>+</sup> (K6.5) and BSR (K4.5) manufactured by Spectrolab have been evaluated for their low temperature and low intensity performance. Sixteen cells of each type were subjected to 11 temperatures and 9 intensities. The sculptured BSR/P<sup>+</sup> (K7) cells provided the greatest maximum power output both at 1 AU and at LTLI conditions. The average efficiencies of this cell were 14.4% at 1 SC/+25°C and 18.5% at 0.086 SC/-100°C.

TM-78306

August 1980

Space Environmental Effects on Materials. R. J. Schwinghamer. Materials and Processes Laboratory. N81-10085

The Space Shuttle will provide a low cost delivery system for Earth orbital payloads by amortizing launch costs through system reusability. This development paves the way for large platforms and structures in space. But successful design of long life platforms and structures for space use requires due consideration of space environmental effects on the materials used. Large space system materials, especially those in geosynchronous Earth orbit (GEO), will be subjected to vacuum, ultraviolet radiation and charged particle radiation which will influence the performance and functional lifetime of the systems. This report describes research oriented toward the acquisition of long term environmental effects data needed to support the design and development of large low Earth orbit (LEO) and GEO space platforms and systems for the next decade.

TM-78307

October 1980

Dynamic Testing of Large Space Structures. R. Ryan, R. Jewell, F. Bugg, W. Ivey, R. McComas, L. Kieffling, and J. Jones. Systems Dynamics Laboratory.

Structural dynamicists are faced with basically an unsolvable problem: the prediction and verification of an analytical structural dynamic model to prescribed accuracy for use in control, loads, pogo, and aeroelastic design verification analysis. These verifications are accomplished through static and dynamic structural tests. This report deals with the subject of state-of-the-art dynamic testing, using as examples testing accomplished on the Space Shuttle and its elements. General conclusions on testing approaches are discussed, as well as future technology requirements.

TM-78308\*

November 1980

Skylab Orbital Lifetime Prediction and Decay Analysis. P. E. Dreher, R. P. Little, and G. Wittenstein. Systems Analysis and Integration Laboratory.

N81-13979

\*See notation page 20.

## NASA TECHNICAL MEMORANDA

This report provides a record (from pre-flight planning to earth impact) of Skylab's orbital lifetime predictions, its actual decay, and analysis thereof. Skylab provided a unique opportunity to develop, confirm and check out procedures and computer programs used for predicting lifetime and reentry. It provided verification of aerodynamic and environment which had been predicted for several aerodynamic configurations. It also provided data on the density model's reaction to rapidly changing solar flux over relatively short time periods. The effects of solar flux (and the uncertainty in the solar flux predictions) on orbital lifetime are discussed.

TM-78309                      October 1980  
Space Transportation System Solid Rocket Booster Thrust Vector Control System. Adas J. Verble, Jr., Alex A. McCool, and Jack H. Potter. Structures and Propulsion Laboratory.

N81-11105

The Solid Rocket Booster, Thrust Vector Control (TVC) system was designed in accordance with the following requirements: self-contained power supply, fail-safe operation, 20 flight uses after exposure to seawater landings, optimized cost, and component interchangeability. Trade studies were performed which led to the selection of a recirculating hydraulic system powered by Auxiliary Power Units (APU) which drive the hydraulic actuators and gimbal the solid rocket motor nozzle. Other approaches for the system design were studied in arriving at the recirculating hydraulic system powered by an APU. These systems must withstand the imposed environment and be usable for a minimum of 20 Space Transportation System flights with a minimum of refurbishment. The TVC system has completed the required qualification and verification tests and is certified for the intended application. Substantiation data will include analytical and test data.

TM-78310                      October 1980  
Pilot Signals for Large Active Retro-Directive Arrays. C. H. Chan. NASA/ASEE Summer Fellowship Program. N81-10238

It has been suggested that for large active retrodirective arrays, as in the solar power system, a two-tone uplink pilot signal with frequencies symmetrically situated around the downlink frequency be used in order to reduce ionospheric biases and to lower the cost since a two-tone receiver is economically much cheaper than a single-tone phase-locked receiver. Unfortunately such a system now faces the following well-known difficulties: (i) the  $\pi$ -ambiguity, (ii) a large phase difference between the downlink and uplink signals.

We show in this report how the  $\pi$ -ambiguity can be easily removed by using a two-tone uplink signal with both frequencies situated at one side of the downlink frequency, and the phase difference can be greatly reduced with a three-tone or a four-tone uplink pilot signal.

TM-78311                      October 1980  
Electrical Torques on the Electrostatic Gyro in the Gyro Relativity Experiment. Peter Eby and Wesley Darbro. Space Sciences Laboratory. N81-10344

This report presents a comprehensive discussion and calculation of electrical torques on an electrostatic gyro as they relate to the Gyroscope Experiment to test General Relativity. Drift rates are computed for some typical state-of-the-art rotors, including higher harmonics in the rotor shape. The effect of orbital averaging of gravity gradient forces, roll averaging of torques, and the effect of spin averaging on the effective shape of the rotor are considered. The basic conclusion is that the electrical torques are reduced sufficiently in a low-g environment to permit a measurement of the relativistic drifts predicted by General Relativity.

## NASA TECHNICAL MEMORANDA

TM-78312                      November 5, 1973  
The Mathematical Model Development  
for the MSFC Skylab Man-in-the-Loop  
Docking Simulator.                      N81-70790

The equations used to drive the Skylab man-in-the-loop docking simulation of MSFC's Comp Lab facility are developed. These include models of the docking contact-capture-latch forces and torques, CMG/TACS and RCS control models, target motion simulator equations, and gravity gradient torques. These equations are currently implemented in the docking simulator which has been and continues to be used in support of Skylab missions. Most noteworthy in this development is the use of a method of "soft constraints" which allows real time simulation of docking impacts on the EAI8900 Hybrid Computer System.

TM-78313                      October 1980  
FY 1980 Scientific and Technical  
Reports, Articles, Papers, and Presentations. Compiled by O. L. White, Management Services Office.                      N81-28036

This document presents formal NASA technical reports, papers published in technical journals, and presentations by MSFC personnel in FY 80. It also includes papers of MSFC contractors.

After being announced in STAR, all of the NASA series reports may be obtained from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

The information in this report may be of value to the scientific and engineering community in determining what information has been published and what is available.

TM-78314                      November 1980  
A Preliminary Look at AVE-SESAME  
IV Conducted on 9-10 May 1979.

Michael J. July and Robert E. Turner.  
Space Sciences Laboratory.                      N81-14552

This report contains information on data collected, synoptic conditions, and severe and unusual weather reported during the AVE-SESAME IV period. The information is preliminary. The purpose of the report is to provide to researchers a preliminary look at conditions during the AVE-SESAME IV period.

TM-78315                      November 1980  
AVE-SESAME IV: 25 mb Sounding  
Data. Meta E. Sienkiewicz, Luke P.  
Gilchrist, and Robert E. Turner. Space  
Sciences Laboratory.                      N81-14553

This report describes the rawinsonde sounding program for the AVE-SESAME IV experiment and presents tabulated data at 25 mb for the 23 National Weather Service and 20 special stations participating in the experiment. Soundings were taken at 3-hr intervals beginning at 1200 GMT on May 9, 1979, and ending at 1200 GMT on May 10, 1979 (nine sounding times). The method of processing is discussed briefly, estimates of the rms errors in the data are presented, and an example of contact data is given. Reasons are given for the termination of soundings below 100 mb, and soundings are listed which exhibit abnormal characteristics.

TM-78316                      November 1980  
Theoretical Regime Diagrams for Thermally Driven Flows in a Beta-Plane Channel in the Presence of Variable Gravity. J. E. Geisler and W. W. Fowlis.  
Space Sciences Laboratory.                      N81-12676

The effect of a power law gravity field on baroclinic instability is examined, with a focus on the case of inverse fifth power gravity, since this is the power law produced when terrestrial gravity is simulated in



spherical geometry by a dielectric force. Growth rates are obtained of unstable normal modes as a function of parameters of the problem by solving a second-order differential equation numerically. Results are compared with those from an earlier study in which gravity was a constant. It is concluded that over the range of parameter space explored here, there is no significant change in the character of theoretical regime diagrams if the vertically averaged gravity is used as parameter.

TM-78317

December 1980

The Swept Angle Retarding Ion Mass Spectrometer - Initial Results from the Michigan Auroral Probe Sounding Rocket. D. L. Reasoner, C. R. Chappell, N. H. Stone, W. E. Sharp, and J. H. Hoffman. Space Sciences Laboratory.

N81-14530

Data from a sounding rocket flight of the Swept Angle Retarding Ion Mass Spectrometer (SARIMS) are presented to demonstrate the capability of the instrument to make measurements of thermal ions which are differential in angle, energy, and mass. The SARIMS was flown on the Michigan Auroral Probe (MAP) over regions characterized first by discrete auroral arcs and later by diffuse precipitation. The instrument measured the temperature, densities, and flow velocities of the ions  $\text{NO}^+$  and  $\text{O}^+$ . Measured  $\text{NO}^+$  densities ranged from  $10^5$  up to  $3 \times 10^5$  ions/cm<sup>3</sup>, while the measured  $\text{O}^+$  densities were a factor of 5-10 less. Ion temperatures ranged from 0.15 up to 0.33 eV. Eastward ion flows of approximately 0.5 km/sec were measured near the arcs, and the observed flow magnitude decreased markedly inside the arcs.

TM-82389

January 1981

Space Shuttle Solid Rocket Booster Recovery Subsystem. Roy E. Runkle. Structures and Propulsion Laboratory.

N81-13990

The design and testing of the Space Shuttle Solid Rocket Booster (SRB) Recovery Subsystem (RSS) posed some unique challenges. The Recovery System components (parachutes, suspension lines, risers, reefing lines, etc.) were of gargantuan dimensions when compared with existing parachutes, such as personnel parachutes or cargo-recovery parachutes. The SRB RSS parachutes were designed to deploy in a severe (200-220 pounds/in.<sup>2</sup> air pressure) environment and safely lower to earth an 85-ton rocket motor casing.

Severe development schedule and funding limitations required dedicated and innovative thinking from a small team of government and contractor personnel. This report describes the studies and the development and testing program that led to a successful design and delivery of all flight hardware to Kennedy Space Center, Florida, on schedule.

TM-82390

January 1981

Steering Law for Parallel Mounted Double-Gimbaled Control Moment Gyros - Revision A. H. F. Kennel. Systems Dynamics Laboratory.

N81-13991

Mounting of double-gimbaled control moment gyros (CMG's) of unlimited outer gimbal angle freedom with all their outer gimbal axes parallel allows drastic simplification of the CMG steering law development in the redundancy management and failure accommodation and in the mounting hardware. The advantages of the parallel mounting for the CMG steering law development are such that a law could be developed which is applicable to any number of CMG's with arbitrary angular momentum. Parallel mounting of the CMG's in conjunction with the steering law can therefore be considered a "CMG kit" suitable for many missions of differing momentum requirements. It also means that increasing momentum demands

## NASA TECHNICAL MEMORANDA

during the design phase of a space vehicle can be easily met by the addition of one or more CMG's of the original momentum capacity rather than a redesign to a larger momentum capacity. Another advantage of the parallel mounting is that the failure of any CMG can be treated like any other, i.e., only one failure mode is possible. The CMG steering law distributes the CMG momentum vectors such that all inner gimbal angles are equal which reduces the rate requirements on the outer gimbal axes. The steering law also spreads the outer gimbals which ensures avoidance of singularities internal to the angular momentum envelope.

This report is an extensive revision of Reference 1 to the extent that a different outer gimbal angle distribution function is used, significantly reducing the software requirements.

TM-82391 January 1981  
An Evaluation of Grease Type Ball Bearing Lubricants Operating in Various Environments (Status Report No. 5).  
E. L. McMurtrey. Materials and Processes Laboratory. N81-16475

Because many future spacecraft or space stations will require mechanisms to operate for longer periods of time in environments which are adverse to most bearing lubricants, a series of tests is continuing to evaluate 38 grease type lubricants in R-4 size bearings in five different environments for a 1-year period. Four repetitions of each test are made to provide statistical samples. These tests have also been used to select four lubricants for 5-year tests in selected environments with five repetitions of each test for statistical samples. At the present time, 100 test sets have been completed and 22 test sets are underway. Three 5-year tests have already been started in (1) continuous and (2) start-stop operation, with both in vacuum at ambient temperatures, and (3) continuous operation at 93.3 °C. To

date, in the 1-year tests, the best results in all environments have been obtained with a high viscosity index perfluoroalkylpolyether (PFPE) grease.

TM-82392 January 1981  
An Extended Classical Solution of the Droplet Growth Problem. B. Jeffrey Anderson, John Hallett, and Maurice Beesley. Space Sciences Laboratory. N81-17383

Problems of applying the classical kinetic theory to the growth of small droplets from the vapor are examined. A solution for the droplet growth equation is derived which is based on the assumption of a diffusive field extending to the drop surface. The method accounts for partial thermal and mass accommodation at the interface and the kinetic limit to the mass and heat fluxes, and it avoids introducing the artifact of a discontinuity in the thermal and vapor field near the droplet. Consideration of the environmental fields in spherical geometry utilizing directional fluxes yields boundary values in terms of known parameters and a new Laplace transform integral. Different initial assumption coupled with this method yield various solutions derived by earlier workers. The solution is applicable to drop sizes both larger and smaller than the mean free path.

TM-82393 January 1981  
Seacoast Stress Corrosion Cracking of Aluminum Alloys. T. S. Humphries and E. E. Nelson. Materials and Processes Laboratory. N81-18164

An investigation of the stress corrosion cracking resistance of high strength, wrought aluminum alloys in a seacoast atmosphere is presented, and the results are compared with those obtained in laboratory tests. Round tensile specimens taken from the short transverse grain direction of aluminum plate and

## NASA TECHNICAL MEMORANDA

stressed up to 100 percent of their yield strengths were exposed to the seacoast at Kennedy Space Center and to alternate immersion in salt water and synthetic seawater. Maximum exposure periods of one year at the seacoast, 0.3 or 0.7 of a month for alternate immersion in salt water, and three months for synthetic seawater are indicated for aluminum alloys to avoid false indications of stress corrosion cracking failure resulting from pitting. Correlation of the test results was very good among the three test media using the selected exposure periods. Therefore, either of the laboratory test media is suitable for evaluating the stress corrosion cracking performance of aluminum alloys in seacoast atmosphere.

TM-82394 January 1981  
The Pyroelectric Properties of TGS for Application in Infrared Detection. R. L. Kroes and D. Reiss. Space Sciences Laboratory. N81-18852

This report describes the pyroelectric property of triglycine sulfate (TGS) and its application in the detection of infrared radiation. The detectivities of pyroelectric detectors and other types of infrared detectors are compared. The thermal response of a pyroelectric detector element and the resulting electrical response are derived in terms of the material parameters. The noise sources which limit the sensitivity of pyroelectric detectors are described, and the noise equivalent power for each noise source is given as a function of frequency and detector area.

TM-82395\*\* January 1981  
Development and Testing of Heat Transport Fluids For Use In Active Solar Heating And Cooling Systems -- Final Report. John C. Parker. Solar Energy Applications Projects Office. N81-16584

This document summarizes the final results of contract NAS8-32255 with Houston

Chemical Company, Corpus Christi, Texas, for the additional development work on heat transport fluids for use with active solar heating and cooling systems. It discusses the intended use of the final report, describes the deliverable end items, lists program objectives, relates how they were accomplished and deals with problems encountered during testing.

The report shows that a certain product tested is marketable and is recommended as being suitable for public use.

TM-82396 January 1981  
Postflight Analysis of The Single-Axis Acoustic System on SPAR VI and Recommendations for Future Flights. R. J. Naumann, W. A. Oran, Roy R. Whymark, and Charles Rey. Space Sciences Laboratory. N81-18860

This report presents the postflight analysis of the single-axis acoustic levitator that was flown on SPAR VI in October 1979. The apparatus malfunctioned. The results of a series of tests, analyses, and investigation of hypotheses that were undertaken to determine the probable cause of failure are presented, together with recommendations for future flights of the apparatus.

The most probable causes of the SPAR VI failure were (1) lower than expected sound intensity due to mechanical degradation of the sound source and (2) an unexpected external force that caused the experiment sample to move radially and eventually be lost from the acoustic energy well.

TM-82397 January 1981  
AVE-SESAME VI: 25-mb Sounding Data. Meta E. Sienkiewicz, Luke P. Gilchrist, and Robert E. Turner. Space Sciences Laboratory. N81-18607

This report describes the rawinsonde sounding program for the AVE-SESAME VI

## NASA TECHNICAL MEMORANDA

experiment and presents tabulated data at 25-mb intervals from the surface to 25 mb for the 23 National Weather Service and 15 special stations participating in the experiment. Soundings were taken at 3-h intervals beginning at 1200 GMT on June 7, 1979, and ending at 1200 GMT on June 8, 1979 (nine sounding times). The method of processing is discussed briefly, estimates of the rms errors in the data presented, an example of contact data given, reasons given for the termination of soundings below 100 mb, and soundings listed which exhibit abnormal characteristics.

TM-82398 January 1981  
A Preliminary Look at AVE-SESAME VI Conducted on 7-8 June 1979.  
Michael July and Robert E. Turner.  
Space Sciences Laboratory.  
N81-18896

This report contains information on data collected, synoptic conditions, and severe and unusual weather reported during the AVE-SESAME VI period. The purpose of the report is to provide to researchers a preliminary look at conditions during the AVE-SESAME VI period, 7-8 June 1979.

TM-82399 January 1981  
Susceptibility Measurements on the Superconducting Properties of Nb-Ge Alloys. Thomas J. Rathz. Space Sciences Laboratory.  
N81-18893

A susceptibility apparatus to measure superconducting properties of samples made in the MSFC Drop Tube has been used to measure the transition temperature ( $T_c$ ) and susceptibilities of Nb and Nb-Ge Alloys prepared in bulk spherical (2-4 diameter) form using a 32 m drop tube in which containerless low-gravity solidification could take place. Results indicate that a drop tube processing environment was beneficial for increasing the  $T_c$  of the superconducting

phase of the material over that of arc-melted material. The increase in  $T_c$  is found to be related to the amount of solidification of the total sample that took place before reaching the bottom of the drop tube. In-phase and quadrature-phase measurements of the specimen's susceptibility indicated that some improvement in homogeneity takes place in drop tube processing. These phase measurements also indicated little or no shielding of a lower  $T_c$  phase by a higher  $T_c$  filamentary structure.

TM-82400 January 1981  
IECM Calibration and Data Reduction Requirements. Fred D. Wills and Charles W. Davis. Space Sciences Laboratory.  
N81-18569

The Induced Environment Contamination Monitor (IECM) tape recorder format, as it relates to the output of meaningful data from the IECM instrument, is explained in this report. Eight-bit words (or bytes) generate numbers that represent voltage levels of electronic detection probes for each experiment. This information is amalgamated by the IECM Data Acquisition and Control System (DACS). In some cases bits represent certain status situations concerning an experiment, such as whether a valve is opened or closed. Voltages are transformed into meaningful physical phenomena through equations of calibration. Data formats and plots are generated as requested for each IECM experimenter.

TM-82401 January 1981  
Equilibrium and Stability of a Satellite Influenced by Gravitational and Aerodynamic Torques. Zachary J. Galaboff. Systems Dynamics Laboratory.  
N81-18078

Equilibrium and stability of a satellite influenced by gravitational and aerodynamic torques are investigated. A circular orbit and

## NASA TECHNICAL MEMORANDA

constant atmospheric density are assumed. Presented is a computer program which determines equilibrium attitudes and the associated eigenvalues of these attitudes. Demonstration of the use of this program is made using the former Skylab satellite as an example.

TM-82402 February 1981  
Evaluation of Several Corrosion Protective Coating Systems on Aluminum.  
R. H. Higgins, Materials and Processes Laboratory.  
N81-19274

A study of several protective coating systems for use on aluminum in seawater/seacoast environments has been conducted. This study was conducted to review the developments that have been made on protective coatings since early in the Space Shuttle program and to perform comparative studies on these coatings to determine their effectiveness for providing corrosion protection during exposure to seawater/seacoast environments. Panels of 2219-T87 aluminum were coated with 21 different systems and exposed to a 5 percent salt spray for 4000 hr. Application properties, adhesion measurements, heat resistance and corrosion protection were evaluated. For comparative studies, the presently specified Bostik epoxy system used on the SRB structures was included. Results of these tests indicate four systems with outstanding performance and four additional systems with protection almost as good. These systems are based on a chromated pretreatment, a chromate epoxy primer, and a polyurethane topcoat. Consideration for one of these systems should be included for those applications where superior corrosion protection for aluminum surfaces is required.

TM-82403 March 1981  
Viscoelastic Propellant Effects on Space Shuttle Dynamics. Frank Bugg, Systems Dynamics Laboratory.  
N81-20289

An extensive program of solid propellant research has been conducted to support the Space Shuttle Dynamics modeling effort. The research is discussed in three parts. The first describes studies performed to define characteristics of the propellant itself, i.e., the stiffness, damping, compressibility, and the effects of many variables on these properties. The second concerns the relationship between the propellant and SRB dynamics, such as effects of propellant stiffness on free-free SRB modes. The third deals with coupled modes of the Shuttle system and the effects of propellant stiffness on SRB/ET interfaces.

TM-82404 March 1981  
Weld Geometry Strength Effect in 2219-T87 Aluminum. A. C. Nunes, Jr., H. L. Novak, and M. C. McIlwain, Materials and Processes Laboratory.  
N81-21172

A theory of the effect of geometry on the mechanical properties of a butt weld joint is worked out based upon the soft interlayer weld model. Tensile tests of 45 TIG butt welds and 6 EB beads-on-plate in 1/4-in. 2219-T87 aluminum plate made under a wide range of heat sink and power input conditions are analyzed using this theory. The analysis indicates that purely geometrical effects dominate in determining variations in weld joint strength with heat sink and power input. Variations in weld dimensions with cooling rate are significant as well as with power input. Weld size is suggested as a better indicator of the condition of a weld joint than energy input.

TM-82405 February 1981  
The MSFC Vector Magnetograph. M. J. Hagyard, N. P. Cumings, and E. A. West, Space Sciences Laboratory.

The NASA/Marshall Space Flight Center's solar vector magnetograph system is

## NASA TECHNICAL MEMORANDA

described; this system allows measurements of all components of the Sun's photospheric magnetic field over a  $5 \times 5$  or  $2.5 \times 2.5$  arc min square field of view with an optimum time resolution of approximately 100 sec and an optimum signal-to-noise of approximately 1000. The basic system components are described, including the optics, detector, digital system, and associated electronics. Automatic sequencing and control functions are outlined as well as manual selections of system parameters which afford unique system flexibility. Results of system calibration and performance are presented, including linearity, dynamic range, uniformity, spatial and spectral resolutions, signal-to-noise, electro-optical retardation and polarization calibration.

**TM-82406** March 1981  
Performance of Photomultiplier Tubes and Sodium Iodide Scintillation Detector Systems. Charles A. Meegan, Space Sciences Laboratory. N81-21280

The performance of photomultiplier tubes (PMT's) and scintillation detector systems incorporating 50.8 by 1.27 cm NaI (Tl) crystals was investigated. The purpose of the investigation was to determine the characteristics of the photomultiplier tubes and optimize the detector geometry for the Burst and Transient Source Experiment (BATSE) on the Gamma Ray Observatory (GRO). This report provides background information on performance characteristics of PMT's and NaI (Tl) detectors, specifies procedures for measurement of relevant parameters, and presents results of these measurements.

**TM-82407** March 1981  
The Passive Optical Sample Assembly (POSA) on STS-1. Roger C. Linton, Space Sciences Laboratory. N81-20868

The Passive Optical Sample Assembly

(POSA), scheduled for flight on Orbital Flight Test 1 (OFT-1), is an instrument to aid in the assessment of contamination hazards to sensitive payloads in the Shuttle cargo bay. It consists of an array of passively deployed samples mounted on the Development Flight Instrumentation (DFI) pallet in the Shuttle cargo bay. This report describes the POSA hardware, the directory of samples together with their intended measurements, and the plan for POSA data analysis.

**TM-82408** March 1981  
Development of Urethane Coating and Potting Material with Improved Hydrolytic and Oxidative Stability. Donald E. Morris, Materials and Processes Laboratory. N81-22192

A series of saturated hydrocarbon-based urethanes was prepared and characterized for hydrolytic and oxidative stability. A series of ether-based urethanes was used as a basis for comparison. The alkane-based urethanes were found to be hydrolytically and oxidatively stable, and had excellent electrical properties. The alkane-based materials absorbed little or no water and were reversion-resistant. There was little loss in hardness or weight when exposed to high temperature and humidity. Dielectric properties were excellent and suffered little adverse effects from the high temperature/humidity conditions. The alkane-based urethanes were not degraded by ozone exposure.

**TM-82409** March 1981  
Considerations on Repeated Repairing of Weldments in Inconel 718 Alloy. E. O. Bayless, C. V. Lovoy, M. C. McIlwain, and P. Munafò, Materials and Processes Laboratory. N81-21171

This report presents the results of a study to determine the effects of repeated weld repairs on the metallurgical characteristics, high cycle fatigue (HCF), and tensile properties of Inconel 718 butt weld joints.

## NASA TECHNICAL MEMORANDA

The study employed 1/4-in. and 1/2-in. thick plates, tungsten inert gas (TIG) welding, and Inconel 718 filler wire. Weld panels were subjected to 2, 6, and 12 repeated repairs and were made in a highly restrained condition. Post weld heat treatments were also conducted with the welded panel in the highly restrained condition.

The study concluded that no significant metallurgical anomaly was evident as a result of up to twelve repeated weld repairs. No degradation in fatigue life was noted for up to twelve repeated repairs. Tensile results from specimens which contained up to twelve repeated weld repairs revealed no significant degradation in UTS and YS. However, a significant decrease in elongation was evident with specimens (solution treated and age-hardened after welding) which contained twelve repeated repairs. The elongation loss was attributed to the presence of a severe notch on each side (fusion line) of the repair weld bead reinforcement. Basically, the weld joint tends to peak more and more with each successive repeated weld repair but, due to a combination of an increase in back-side metal drop through and distortion restraint during repeated repairing, the peak projection develops as a shallow notch on each side of the weld repair. This study shows that the severity of these notches increases with increasing numbers of repeated repairs.

TM-82410 April 1981  
Materials Processing in Space (MPS)  
Program Description. N81-22065

The intent of this document is to provide a brief insight into the scientific rationale of MPS, and to describe a comprehensive and cohesive approach for implementation and integration of the many, diverse aspects of MPS.

The programmatic and management functions are intended to apply to all projects

and activities implemented under MPS. It is intended, further, that specific project plans, providing project unique details, will be appended to this document for major endeavors such as the Space Processing Applications Rocket (SPAR) Project, the Materials Experiment Assembly (MEA) Project, the MPS/Spacelab (MPS/SL) Project, and the Materials Experiment Carrier (MEC) Payloads.

The MEC development is expected to be an Office of Space Transportation Systems (OSTS) budgeted project, done in conjunction with the Office of Space and Terrestrial Applications (OSTA) and managed by the MPS Projects Office at Marshall Space Flight Center (MSFC); a separate project plan with joint OSTS/OSTA approval is anticipated for that project.

TM-82411 April 1981  
Chemical Etching for Automatic Processing of Integrated Circuits. Bobby W. Kennedy. Electronics and Control Laboratory. N81-74978

This report presents a discussion of Chemical Etching for automatic processing of integrated circuits including the wafer carrier and loading from a receiving air track into automatic furnaces and unloading onto a sending air track.

TM-82412 April 1981  
Low Drag Attitude Control for Skylab Orbital Lifetime Extension. John R. Glaese and Hans F. Kennel. Systems Dynamics Laboratory. N81-22074

In the fall of 1977 it was determined that Skylab had started to tumble and that the original orbit lifetime predictions were much too optimistic. A decision had to be made whether to accept an early uncontrolled reentry with its inherent risks or try to attempt to control Skylab to a lower drag attitude in the hope that there was enough

# NASA TECHNICAL MEMORANDA

**time to develop a Teleoperator Retrieval System, bring it up on the Space Shuttle and then decide whether to boost Skylab to a higher longer life orbit or to reenter it in a controlled fashion.**

In the following the end-on-velocity (EOVV) control method is documented, which was successfully applied for about half a year to keep Skylab in a low-drag attitude with the aid of the control moment gyros and a minimal expenditure of attitude control gas.

TM-82413 March 1981  
The Pinhole/Occulter Facility. H. S.  
Hudson, J. L. Kohl, R. P. Lin, R. M.  
MacQueen, E. Tandberg-Hanssen, and  
J. R. Dabbs. Space Sciences Laboratory.  
N81-22895

A large occulting system in space can be used for high-resolution X-ray observations and for large-aperture coronagraphic observations in visible and UV light. The X-ray observations will combine high angular resolution in hard ( $>10$  keV) X-radiation with the high sensitivity of a multiple-pinhole camera, and will permit sensitive observations of bremsstrahlung from nonthermal particles in the corona. The large-aperture coronagraphs have two major advantages: high angular resolution and good photon collection. This will permit observations of small-scale structures in the corona for the first time and will give sufficient counting rates above the coronal background rates for sensitive diagnostic analysis of intensities and line profiles for coronal structures in the solar wind acceleration region.

This document describes the technical basis for performing observations with a large occulting system in these three wavelength ranges. A preliminary description of a Pin-hole/Occulter Facility presently being considered for Spacelab is given, together with some indications about future developments.

**TM-82414** **April 1981**  
**Solar Energy Absorption Characteristics**  
**and The Effects of Heat On The Optical**  
**Properties of Several Coatings. J. R.**  
**Lowery. Materials and Processes Lab-**  
**oratory.** **N81-22474**

This study was conducted to determine the solar energy absorption characteristics of several high-temperature coatings and to evaluate the effects of heat on these coatings. Included in the investigation were an electroplated alloy of black chrome and vanadium, electroplated black chrome, and chemically colored 316 stainless steel. The results of this study showed that each of the coatings possessed good selective solar energy absorption properties at laboratory ambient temperature. Measured at a temperature of 700°K (800°F), the emmittances of black chrome, black chrome-vanadium, and colored stainless steel were 0.11, 0.61, and 0.15, respectively. Black chrome and black chrome-vanadium did not degrade optically in the presence of high heat [811°K (1000°F)]. Chemically colored stainless steel showed slight optical degradation when exposed to moderately high heat [616°K (650°F)], but showed more severe degradation at exposure temperatures beyond this level. Each of the coatings showed good corrosion resistance to a salt-spray environment.

TM-82415\*\* April 1981  
Development And Testing Of Thermal  
Energy Storage Modules For Use In  
Active Solar Heating and Cooling Sys-  
tems — Final Report. John C. Parker.  
Solar Energy Applications Projects  
Office. N81-23604

This document summarizes the final results of contract NAS8-32254 with Artech Corporation, Falls Church, Virginia, for the additional development work on thermal energy storage modules for use with active solar heating and cooling systems. It discusses the intended use of the final report.



## NASA TECHNICAL MEMORANDA

describes the deliverable end items, lists program objectives, relates how they were accomplished and deals with problems encountered and their solutions.

The report shows that the product developed and tested is marketable and is recommended as being suitable for public use.

TM-82416 May 1981  
A Preliminary Look at AVE-SESAME V  
Conducted on 20-21 May 1979, Michael  
J. July and Robert E. Turner. Space  
Sciences Laboratory. N81-24680

This report contains information on data collected, synoptic conditions, and severe and unusual weather reported during the AVE-SESAME V period. The information is preliminary. The purpose of the report is to provide to researchers a preliminary look at conditions during the AVE-SESAME V period.

TM-82417 May 1981  
AVE-SESAME V: 25-mb Sounding Data.  
Meta E. Sienkiewicz, Luke P. Gilchrist,  
and Robert E. Turner. Space Sciences  
Laboratory. N81-24651

This report describes the rawinsonde sounding program for the AVE-SESAME V experiment and presents tabulated data at 25-mb intervals for the 23 National Weather Service stations and 20 special stations participating in the experiment. Soundings were taken at 3-hr intervals beginning at 1200 GMT on May 20, 1979, and ending at 1200 GMT on May 21, 1979 (nine sounding times). A tenth sounding was taken at many special stations between 2100 and 0000 GMT on May 20. The method of processing is discussed briefly, estimates of the rms errors in the data are presented, and an example of contact data is given. Reasons are given for

the termination of soundings below 100 mb, and soundings with abnormal characteristics are listed.

TM-82418 April 1981  
The Retarding Ion Mass Spectrometer  
on Dynamics Explorer-A. C. R.  
Chappell, S. A. Fields, C. R. Baugher,  
J. H. Hoffman, W. B. Hanson, W. W.  
Wright, H. D. Hammack, C. R. Carignan,  
and A. F. Nagy. Space Sciences Labora-  
tory. N81-24908

The Retarding Ion Mass Spectrometer (RIMS) for Dynamics Explorer-A is an instrument designed to measure the details of the thermal plasma distribution. It combines the ion temperature-determining capability of the retarding potential analyzer with the compositional capabilities of the mass spectrometer and adds multiple sensor heads to sample all directions relative to the spacecraft ram direction. This report describes the RIMS, its operational modes, the instrument calibration, the data reduction plan, and the anticipated results.

TM-82419 May 1981  
Project Resource Reallocation Algor-  
ithm. J. E. Myers. Cost Analysis Office.  
N81-25861

Project schedules are an important parameter in industrial-engineering-type man-hour and material cost estimates. An existing computer tool (PACE-Pricing and Cost Estimating) generates a cost estimate from resource estimates by Work Breakdown Structure (WBS) and element-of-cost based on a specific project schedule. Project schedules often change, requiring some methodology for adjusting baseline cost estimates. An algorithm has been developed and is described herein which performs a linear expansion or contraction of the baseline project resource distribution in proportion to the project

## NASA TECHNICAL MEMORANDA

schedule expansion or contraction. Input to the algorithm consists of the deck of cards (PACE input data) prepared for the baseline project schedule as well as a specification of the nature of the baseline schedule change. Output of the algorithm is a new deck of cards with all WBS block and element-of-cost estimates redistributed for the new project schedule. This new deck can be processed through PACE to produce a detailed cost estimate for the new schedule.

TM-82420

April 1981

Emergency Relief Venting of the Infrared Telescope Liquid Helium Dewar -- Second Edition. Eugene W. Urban, Space Sciences Laboratory. N81-24302

An updated analysis is made of the emergency relief venting of the liquid helium dewar of the Spacelab 2 Infrared Telescope experiment in the event of a massive failure of the dewar guard vacuum. Such a failure, resulting from a major accident, could cause rapid heating and pressurization of the liquid helium in the dewar and lead to relief venting through the emergency relief system. This report estimates the heat input from an accident for various fluid conditions in the dewar and considers the relief process as it takes place through one or both of the emergency relief paths. In the original edition of this report it was assumed that the burst diaphragms in the dewar relief paths would rupture at a pressure of 65 psi differential or 4.4 atmospheres. A detailed analysis of this case was performed, and the results constitute the major portion of this revised report. It has, in fact, proved necessary to use burst diaphragms in the dewar which rupture at 115 psid or 7.8 atmospheres. An analysis of this case has been carried out and shows that when the high pressure diaphragm rupture occurs, the dewar pressure falls within 8 s to below the 4.4 atmospheres for which the original analysis was performed, and thereafter it remains below that level. It is, therefore, shown that under all reasonable circumstances the dewar will safely relieve

itself.

This report supersedes NASA TM-78271, March 1980, and should be used in place of it.

TM-82421

June 1, 1981

Passive Optical Sample Assembly (POSA) for STS-1 -- Quick-Look Post-mission Report. Roger C. Linton and Edgar R. Miller. Space Sciences Laboratory. N81-24161

The Passive Optical Sample Assembly (POSA) is a passively deployed array of contamination-sensitive samples. A POSA unit was mounted and flown in the cargo bay of the Space Shuttle Columbia during the first Orbital Flight Test (OFT-1). A similar unit was mounted in a different location in the cargo bay at Dryden Flight Research Center during the postflight operations there prior to the ferry flight return of Columbia to Kennedy Space Center.

The samples in both POSA arrays were subjected to a series of optical and analytical measurements prior to delivery for installation in the cargo bay and after retrieval of the flight hardware. This report presents a quick-look summary of the results of a comparison of the two series of measurements. A more detailed analysis will be provided later in a separate publication.

TM-82422

April 1981

Payload Operations Control Center (POCC) Timeline Analysis Program. Dr. David L. Shipman, Steven R. Neman, and E. Steven Terry. Systems Analysis and Integration Laboratory. N81-24845

This document is a user's manual for the operation of the Payload Operations Control Center (POCC) Timeline Analysis Program which is used to provide POCC activity and resource information as a function of mission time. This program is fully

## NASA TECHNICAL MEMORANDA

automated and interactive, and is equipped with tutorial displays. The tutorial displays are sufficiently detailed for use by a program analyst having no computer experience. The POCC Timeline Analysis Program is designed to operate on the VAX/VMS version V2.1 computer system.

TM-82423 May 1981  
Undercooling Measurement in a Low-Gravity Containerless Environment.  
Michael B. Robinson. Space Sciences Laboratory. N81-25092

This report describes a technique for measuring the amount of undercooling for samples processed in a low-gravity containerless environment. The time of undercooling is determined by measuring the time of cooling before nucleation and recalescence by two infrared detectors. Once the cooling curve for each drop is calculated, the amount of undercooling can then be found. The technique is demonstrated by measuring the amount of undercooling for drops of pure niobium and select compositions of the niobium-germanium alloy system while free falling in a 32 m evacuated drop tube.

Before undercooling curves for the niobium-germanium alloy drops could be calculated, it was necessary to measure the total hemispherical emissivities and specific heats for these materials because there is a total absence of such thermophysical properties in the literature. These properties were measured using a high-temperature containerless calorimeter. Also, a brief overview of the effect of undercooling on drops of niobium and niobium-germanium is given.

TM-82424 October 1980  
Lox/Gox Related Failures During Space Shuttle Main Engine Development.  
C. E. Cataldo. Materials and Processes Laboratory. N81-27192

Specific rocket engine hardware and test facility system failures are described which were caused by high pressure liquid and/or gaseous oxygen reactions. The failures described were encountered during the development and testing of the Space Shuttle Main Engine. Failure mechanisms are discussed as well as corrective actions taken to prevent or reduce the potential of future failures.

TM-82425 July 1981  
Materials Processing in Space: A Survey of Refereed Open Literature Publications. Compiled by E. Pentecost. Space Sciences Laboratory. N81-28112

This document is a bibliography by year of the research published in the open literature by the workers in the Materials Processing in Space program. This work was sponsored by NASA, either directly or indirectly, and generally pertains to the influence (or lack of influence) of gravity on processes involved in crystal growth, solidification, fluid transport, containerless phenomena, and various separation techniques of interest to the biomedical community. Also included are studies of the possibilities of using the high vacuum in the wake of orbiting vehicles for performing processes involving large heat loads and evolution of gases.

TM-82426 June 1981  
Corrosion Fatigue of Inconel 718 and Incoloy 903. D. B. Franklin and E. E. Nelson. N81-28232

Corrosion fatigue tests were conducted on Inconel 718 and Incoloy 903 in distilled water, 500 ppm NaCl, and 3.5% NaCl. Results were compared to the endurance limit in air. For Inconel 718, the Corrosion Fatigue Strength (CFS) in 3.5% NaCl was 338 MPa (49 ksi) or 75 percent of the endurance limit. For Incoloy 903, the CFS ranged from 234

## NASA TECHNICAL MEMORANDA

MPa (34 ksi) in distilled water (68 percent of the endurance limit) to 103 MPa (15 ksi) in 3.5% of NaCl (30 percent of the endurance limit). These results indicate that, for components which have limited fatigue life, an evaluation of the combined effects of fatigue and the corrosive atmosphere must be considered in projecting useful lifetimes.

**TM-82427** **July 1981**  
Survey of The U. S. Materials Processing and Manufacturing in Space Program. E. C. McKannan, Materials Processing in Space Projects Office. **N81-27150**

The primary motivation of the program is to use the unique environments of space for scientific and commercial applications. The elimination of the Earth's gravity during the production of common materials affords opportunities for understanding and improving ground-based methods or, where practical and economical, producing select materials in space. Large factories or mills producing huge quantities of materials, as is often the case on Earth, are not expected in space in the near future. Materials that might be produced in space, typically, would be of low-volume but of high-value commercial interest.

**TM-82428** **May 1981**  
Fracture Analysis of HPOTP Bearing Balls. Biliyar N. Bhat, Materials and Processes Laboratory. **N81-28442**

This report presents the fracture analysis conducted on four HPOTP (High Pressure Oxygen Turbopump) bearing balls from the SSME (Space Shuttle Main Engine). Non-destructive evaluation, optical microscopy, and transmission microscopy techniques were used in the analysis. The results showed that the cracks are initiated at or close to the ball surface under conditions of high cyclic stresses and high coefficient of friction. The cracks lead to spalls and subsequent crack

propagation seems to occur by fatigue mode under concentrated loading of cyclic nature.

**TM-82429** **June 1981**  
An Investigation of Assembly and Performance of A Resistoflex Dynatube 1/4 Inch Fitting. J. H. Ehl, Materials and Processes Laboratory.

Installation of Resistoflex dynatube fittings on 1/4 in. tubing is sensitive to workmanship and to the state of repair of the installation tooling. Tooling with very slight out-of-specification imperfections will produce less than optimum swaged fittings. This investigation included fabrication of a significant quantity of samples, X-rays to determine the depth of swage and static and dynamic testing to determine joint performance.

**TM-82430** **July 8, 1981**  
Software Control Program for 25 kW Breadboard Testing. J. A. Pajek. **N81-30814**

A data acquisition software program has been developed to operate in conjunction with the automated control system of the 25 kW PM EPS Breadboard Test Facility. The program provides limited interactive control of the Breadboard Test while acquiring data and monitoring parameters, allowing unattended continuous operation.

The Breadboard Test facility has two positions for operating separate configurations. A block diagram of a typical test configuration is shown in Fig. 1. The main variable in each test setup is the high voltage battery. The initial test battery contains 112, 33 AH, NI-CD cells each. The second test battery contains 88, 55 AH, NI-CD cells arranged in four modules of 22 cells each. Current testing will be limited to using a 28 vdc load bus, but the capability for testing

## NASA TECHNICAL MEMORANDA

with a high voltage bus (110 v DC or higher) has been included in the facility and equipment design.

**TM-82431** April 1981  
Evaluation of Anti-Freeze Viscosity Modifier for Potential External Tank Applications. Robert O. L. Lynn. Materials and Processes Laboratory. N81-30169

Viscosity modifiers and gelling agents have been evaluated in combination with ethylene glycol and dimethyl sulfoxide water eutectics. Pectin and agarose were found to gel these autectics effectively in low concentration, but the anti-freeze protection afforded by these compositions was found to be marginal in simulations of the intended applications. Oxygen vent shutters and vertical metallic surfaces were simulated, with water supplied as a spray, dropwise, and by condensation from the air.

**TM-82432** May 1981  
Atmospheric Observations for STS-1 Landing. Robert E. Turner, James E. Arnold, and Gregory S. Wilson. Space Sciences Laboratory. N81-30740

A summary of synoptic weather conditions existing over the western United States is given for the time of Shuttle descent into Edwards Air Force Base, California. The techniques and methods used to furnish synoptic atmospheric data at the surface and aloft for flight verification of the STS-1 Orbiter during its descent into Edwards Air Force Base are specified. Examples of the upper-level data set are given.

**TM-82433\*** May 1981  
Space Processing Applications Rocket Project, SPAR VI Final Report. Compiled by R. Chassay.

The Space Processing Applications Rocket Project (SPAR) VI Final Report contains the compilation of the postflight reports of each of the principal investigators of the four selected science payloads, in addition to the engineering report as documented by the Marshall Space Flight Center (MSFC). This combined effort also describes pertinent portions of ground-based research leading to the ultimate selection of the flight sample composition, including design, fabrication and testing, all of which are expected to contribute immeasurably to an improved comprehension of containerless processing in space.

The SPAR project is coordinated and managed by MSFC as part of the Materials Processing in Space (MPS) program of the Office of Space and Terrestrial Applications (OSTA) of NASA Headquarters.

This technical memorandum is directed entirely to the payload manifest flown in the sixth of a series of SPAR flights conducted at the White Sands Missile Range (WSMR) and includes the experiments entitled "Containerless Processing of Glass," "Epitaxial Growth of Single Crystal Films," "Containerless Processing Technology," and "Directional Solidification of Magnetic Composites."

**TM-82434** July 1981  
Doppler-Cancelled Response to VLF Gravitational Waves. Alessandro Caporali. Space Sciences Laboratory. N81-29311

This report discusses the interaction of long periodic gravitational waves with a three-link microwave system known as the Doppler Cancelling System. This system, which was developed for a gravitational red-shift experiment, uses on-way and two-way

## NASA TECHNICAL MEMORANDA

Doppler information to construct the beat signal of two reference oscillators moving with respect to each other. The geometric optics approximation is used to derive the frequency shift produced on a light signal propagating in a gravitational wave space-time. The signature left on the Doppler-cancelled beat by bursts and continuous gravitational waves is analyzed. A comparison is made between the response to gravitational waves of the Doppler Cancelling System and that of a (NASA) Doppler tracking system which employs two-way, round-trip radio waves. A three-fold repetition of the gravitational wave form is found to be a common feature of the response functions of both systems. These two functions otherwise exhibit interesting differences.

TM-82435

August 1981

Accommodations Analysis: Spaceborne Doppler Lidar Wind Measuring System.

This technical memorandum summarizes an accommodations analysis performed by the MSFC Preliminary Design Office for a spaceborne doppler lidar wind measuring system. A dedicated, free-flying spacecraft design concept is described. Mass and beginning-of-life power requirements are estimated at 2260 kg and 6.0 - 8.5 kW, respectively, to support a pulsed, CO<sub>2</sub>, doppler lidar having a pulse energy of 10 J, pulse rate of 8 Hz, and efficiency of approximately 5%. Under the assumptions of the analysis, such a system would provide wind measurements on a global scale, with accuracies of a few meters per second.

TM-82436

July 1981

Atmospheric Environment for Space Shuttle (STS-1) Launch. D. L. Johnson, G. Jasper, and S. C. Brown. Space Sciences Laboratory.

This report presents a summary of selected atmospheric conditions observed near

Space Shuttle STS-1 launch time on April 12, 1981, at Kennedy Space Center, Florida. Values of ambient pressure, temperature, moisture, ground winds, visual observations (cloud), and winds aloft are included. The sequence of prelaunch biosphere measured vertical wind profiles is given in this report. Also presented are the wind and thermodynamic parameters measured at the surface and aloft in the SRB descent/impact ocean area. Final meteorological data tapes for STS-1 vehicle ascent and SRB descent have been constructed which consist of wind and thermodynamic parameters versus altitude. The STS-1 ascent meteorological data tape has been constructed by Marshall Space Flight Center in response to Shuttle task agreement No. 989-13-22-368 with Johnson Space Center.

TM-82437

August 1981

Holographic Microscopy Studies of Emulsions. William K. Witherow. Space Sciences Laboratory. N81-30212

A holographic microscopy system that will record and observe the dynamic properties of separation in dispersed immiscible fluids is described in detail. This report briefly reviews the requirements of holography. The holographic construction system and reconstruction system that were used to obtain particle sizes and distribution information from the holograms are also described.

The holographic microscopy system is then used to observe the phase separating processes in immiscible fluids that have been isothermally cooled into the two-phase region. Nucleation, growth rates, coalescence, and particle motion are successfully demonstrated with this system. Thus, a holographic particle sizing system with a resolution of 2  $\mu\text{m}$  and a field of view of 100  $\text{cm}^3$  has been developed that will provide the capability of testing the theories of separating immiscible fluids for particle number densities in the range of 10 to 10<sup>7</sup> particles/cm<sup>3</sup>.

## NASA TECHNICAL MEMORANDA

TM-82438

June 1981

Toward A Space Materials Systems Program, Georg F. von Tiesenhausen, Advanced Systems Office.

A program implementation model is presented which covers the early stages of space material processing and manufacturing. The model includes descriptions of major program elements, development and experiment requirements in space materials processing and manufacturing, and an integration of the model into NASA's long range plans as well as its evolution from present Materials Processing in Space plans.

TM-82439

August 1981

Solid Rocket Booster Thrust Vector Control -- V-2 Off-Nominal Testing. Boris Pagan, Structures and Propulsion Laboratory.

This report presents the results of the V-2 off-nominal test sequence performed on the Space Shuttle solid rocket booster thrust vector control (SRB TVC) subsystem by the Marshall Space Flight Center, Huntsville, Alabama. These tests were performed between September 1979 and July 1980, per paragraph 10, SE-019-098-2H, SRB TVC Overall Systems Test Requirements.

A discussion of the overall TVC subsystem performance is presented. In addition, test objectives, detail results, and data are included for general information.

TM-82440

September 1981

MSFC Evaluation of the Space Fabrication Demonstration System (Beam Builder). E. O. Adams and C. N. Irvine, Materials and Processes Laboratory.

The Grumman/MSFC beam builder, designed and manufactured as a ground demonstration model, is a precursor to a machine for use in the space environment,

transportable by the Space Shuttle. The ultimate purpose is to provide the capability to automatically fabricate triangular truss beams in low Earth orbit with a highly reliable machine that requires a minimum of in-space maintenance and repair. This report provides a performance assessment of the beam builder, which was fabricated under contract NAS8-32472 from commercial hardware.

TM-82441

August 1981

Vector Wind Profile Gust Model. S. I. Adelfang and O. E. Smith, Space Sciences Laboratory.

This report summarizes results from a study which had the objective of developing a vector wind gust model that is suitable for orbital flight test operations and trade studies. Emphasis is given to verification of the hypothesis that gust component variables are gamma distributed, gust modulus is approximately Weibull distributed, and zonal and meridional gust components are bivariate gamma distributed. A method of testing for bivariate gamma distributed variables is described, two distributions for gust modulus are described, the results of extensive hypothesis testing of one of the distributions are presented, and the validity of the gamma distribution for representation of gust component variables is established.

TM-82442\*\*

September 25, 1981

Solar Cooling System Performance, Frenchman's Reef Hotel, St. Thomas, U. S. Virgin Islands -- Final Report. Harry Harber.

This report is a part of the Solar Heating and Cooling Development Program funded by the Department of Energy and is one of a series of reports describing the operational and thermal performance of a variety of solar systems installed in Operational Test Sites.

## NASA TECHNICAL MEMORANDA

The Solar Cooling System installed in the Frenchman's Reef Resort Hotel Test Site, St. Thomas, U. S. Virgin Islands, used 956 Sunmaster Corporation evacuated glass tube collector modules which provide an effective solar collector aperture of 13,384 square feet. The system consists of the collectors, two 2500 gallon tanks, pumps, an Andover Controls Corporation computerized controller, a large solar optimized Carrier Corporation industrial sized lithium bromide absorption chiller, and associated plumbing. Solar heated water is pumped through the system to the designed public areas such as lobby, lounges, restaurant and hallways. Auxiliary heat is provided by steam and heat exchanger to supplement the solar heat.

TM-82443

1981

Materials Processing in Space Program Tasks. Compiled by E. Pentecost. Space Sciences Laboratory.

This report is a compilation of the active research tasks as of the end of fiscal year 1981 of the Materials Processing in Space

Program, NASA Office of Space and Terrestrial Applications, involving several NASA Centers and other organizations. The purpose of this document is to provide an overview of the program scope for managers and scientists in industry, university, and government communities. The report is structured to include an introductory description of the program, its history, strategy and overall goal; identification of the organizational structures and people involved; and a description of each research task together with a list of recent publications.

The tasks are grouped into four categories: Crystal Growth; Solidification of Metals, Alloys, and Composites; Fluids, Transports, and Chemical Processes, and Ultrahigh Vacuum and Containerless Processing Technologies. In many cases a task is placed in more than one category. For example, studies involving fluid dynamics of crystal growth were entered in both Crystal Growth and Fluids, Transports, and Chemical Processes. This insures complete coverage of each category.

\*Blue cover reports printed at Langley.

\*\*DOE/NASA reports.



TP-1873

May 1981

Life Test of a Nickel Cadmium Battery With a Protection/Reconditioning Circuit. John R. Lanier, Jr., and John R. Bush, Jr. Electronics and Control Laboratory. N81-24167

This report discusses the results of a Ni-Cd battery test over a period of 8 years, 2 months and 44,213 simulated low earth orbits. The battery cells were protected against overdischarge and reversal at discharge rates up to 25 amperes (1.25C) by a battery protection and reconditioning circuit (BPRC). The circuit performed flawlessly during the test, and proved its value, both as a battery reconditioner and a cell protection device. Battery cell failures are also discussed. The test demonstrated the viability of using Ni-Cd batteries at depths-of-discharge up to 25 percent for over 5 years in a low Earth orbit.

TP-1900

August 1981

Development of a Silane-Hydrolyzate Binder for UV-Resistant Thermal Control Coatings. W. J. Patterson. Materials and Processes Laboratory.

Detailed characterization and formulation studies have been performed on a methyltriethoxysilane hydrolyzate as a binder for thermal control coatings. The binder was optimized by varying hydrolysis temperature, time, catalyst type, and water concentration. The candidate coating formulations, based on this binder with  $\text{TiO}_2$  pigment, were optimized via a detailed series of sprayed test panels that included the parameters of binder/pigment ratio, ethanol content, pigment particle size, coating thickness and cure conditions. A typical optimized coating was prepared by acetic acid-catalyzed hydrolysis of methyltriethoxysilane with 3.25 mol-equivalents of water over a 24 hour period at room temperature. The resulting hydrolyzate was directly mixed with pre-milled  $\text{TiO}_2$ ) 12

grams pigment/26 grams binder) to yield a sprayable consistency. Panels were sprayed to result in a nominal cured coating thickness of 2 mils. Cure was affected by air drying for 24 hr at room temperature plus 72 hr at  $150^\circ\text{F}$ . These coatings are typically extremely tough and abrasion-resistant, with an absorptance ( $\alpha$ ) of 0.20 and emittance ( $\epsilon$ ) of 0.89. No significant coating damage was observed in the mandrel bend test, even after exposure to thermal cycling from  $-160^\circ$  to  $160^\circ\text{F}$ . Vacuum exposure of the coatings for 930 hours at 1 equivalent UV sun resulted in no visible degradation and no significant increase in absorptance.

TP-1912

September 1981

Feasibility Study of LITVC for Shuttle SRB. C. L. Martin and L. B. Powers. Structures and Propulsion Laboratory.

This report presents an analysis of a Liquid Injection Thrust Vector Control (LITVC) system for the Shuttle Solid Rocket Booster (SRB). A performance analysis which compares LITVC with the SRB baseline flexible seal is followed by a table of LITVC advantages and disadvantages.

The analysis concludes that LITVC does not look attractive for use on the SRBs at the present time because of the high duty cycle requirements and the cost and effort associated with implementing a major complex system.

TP-1925

September 1981

Avenues and Incentives for Commercial Use of a Low-Gravity Environment. Richard L. Brown and Lowell K. Zoller. Materials Processing in Space Projects Office.

One of the unique and new technologies which have emerged from the space program is the processing of materials in a low-gravity

(low-g) or microgravity ( $10^{-6}$  g to  $10^{-2}$  g) environment. The reduction or elimination of the pervasive influences of gravity on process mechanisms affords opportunities for understanding and improving ground-based processes and for creating unique materials. The primary goal of NASA's present work in the field is to realize scientific and commercial utilization of the low-g environment for materials research and for process and product development. For the next several years, any products of commercial interest which necessitate processing in space will probably be low volume, high value items. To encourage the commercialization of materials processing in low-g, NASA, in parallel with establishing and demonstrating the scientific/technological precepts for analyzing and using a low-g environment, is establishing the legal and management mechanisms to share in the cost and risk of early commercial ventures, and is now working with commercial firms on a case-by-case basis to explore applications of this new technology to specific needs of the company.

TP-1932

July 1981

Space Shuttle Main Engine Controller.  
Russell M. Mattox and Dr. J. B. White.  
Data Systems Laboratory.

A technical description of the Space Shuttle Main Engine Controller which provides engine checkout prior to launch, engine control and monitoring during launch, and engine safing and monitoring in orbit, is presented. Each of the major controller sub-assemblies, the central processing unit, the computer interface electronics, the input electronics, the output electronics, and the power supplies are described and discussed in detail along with engine and orbiter interfaces and operational requirements.

The controller represents a unique application of digital concepts, techniques, and technology in monitoring, managing, and

controlling a high performance rocket engine propulsion system. The operational requirements placed on the controller, the extremely harsh operating environment to which it is exposed, and the reliability demanded, result in the most complex and ruggedized digital system ever designed, fabricated, and flown.

TP-1933

June 1981

The Aerodynamics of Bodies in a Rarefied Ionized Gas with Applications to Spacecraft Environmental Dynamics.  
Nobie H. Stone. Space Sciences Laboratory.

This study consists of two parts: an experimental parametric investigation and an in-depth critical review of knowledge in the field derived from previous experimental investigations, theoretical treatments, and ionospheric satellite data. The objectives are to provide a parametric description of the electrostatic interaction of a mesosonic, collisionless plasma with conducting bodies on the order of 1 to 10 Debye lengths in size, and to extend this description to the satellite-ionospheric interaction, where possible.

New experimental findings include: (1) converging ion streams in the near wake whose inclination to the wake axis and crossing point location depend on  $\Phi_b$  and  $[SR_d^{0.24}/|\Phi_b|^{1/2}]$ , respectively, where  $\Phi_b$  is the normalized body potential,  $S$ , the ion acoustic Mach number, and  $R_d$ , the Debye ratio; (2) that two mechanisms with different  $\Phi_b$  dependences create the mid-wake axial ion peak whose maximum amplitude and width depend on  $[S/|\Phi_b|^{1/2}]$  and  $|\Phi_b|^{-1/2}$ , respectively; (3) the morphology and amplitude of the axial ion peak depend on the geometry of the plasma sheath, which varies with thickness (and therefore  $R_d$  and  $\Phi_b$ ) for bodies with square cross sections, but is independent of thickness for spherical and long cylindrical bodies; (4) the wake of the geometrically complex body appears to be a

linear superposition of the wakes of its simple geometric components; (5) previously observed electron heating may be explained by a wave-particle interaction resulting from a two-stream instability produced by fast, plasma stream ions passing through slow, charge exchange ions; and (6) vector ion flux measurements show converging ion streams at the wake axis and direct evidence of ion streams deflected from the wake axis by the positive space charge potential associated with the axial ion peak.

The extension to the satellite-ionospheric interaction utilizes qualitative scaling and indicates that similar, but smaller amplitude, wake structures may be expected for small or highly charged bodies. However, for large bodies at small potentials, the structure may be diffused by the thermal ion motion and the dispersion resulting for space charge potentials.

TP-1939

August 1981

**Concept for a Power System Controller for Large Space Electrical Power Systems.** Louis F. Lollar, John R. Lanier, Jr., and James R. Graves. Prepared by Electronics and Control Laboratory, Science and Engineering.

A need for autonomous control of large electrical power systems has emerged. A Marshall Space Flight Center Director's Discretionary Fund task is undertaken to develop technology for a fail-operational Power System Controller (PSC) utilizing microprocessor technology for managing the distribution and power processor subsystems of a large multi-kW space Electrical Power System. The task involved determining the specific functions which must be performed by the PSC, determining the best microprocessor available to do the job, and determining the feasibility, cost savings, and applications of a PSC. A limited function breadboard version of a PSC was developed to demonstrate the concept and potential cost savings.

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**RUSH, J. E.**  
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**STEPHENS, W. K.**

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- KOEPF, DAVID FWG Associates, Inc.  
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**PATTY, S. R.**

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**BAILEY, R. L.** Jet Propulsion Laboratory Shuttle Solid Rocket Motor Nozzle Alternate Ablative Evaluation. For presentation at the AIAA/SAE/ASME 17th Joint Propulsion Conference to be held in Colorado Springs, CO, on July 26-30, 1981.

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**FICHTL, GEORGE H.** ES82  
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- RAY, J. R.** ES63  
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- REASONER, DAVID L.** ES53  
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- REASONER, DAVID L.** ES53  
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- RHODES, PERCY H.** ES73  
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- ROBINSON, M. B.** ES74  
**RATHZ, R. J.** ES74  
**LACY, L. L.** Exxon  
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- ROSE, R. E.** TRW  
**NAKANO, H.** TRW  
**STAFSA, J. A.** TRW  
**BRADY, W. L.** FA81  
The Recovery of the HEAO-2 Observatory. For presentation at the AAS Annual Rocky Mountain Guidance and Control Conference to be held at Keystone, CO, on January 31-February 4, 1981.
- RUSH, J. E.**  
University of Alabama in Huntsville
- STEPHENS, W. K.**  
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- SCHAFER, C. F.** ES82  
**HOLLAND, R. L.** ES82  
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- SEKIHARA, K.** ES83  
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**SIMS, JOHN H.** JA31  
**DODECK, HAUKE** ESA/SPICE  
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**SLOYER, JOHN L.** ES73  
**McGUIRE, JANICE K.** ES73  
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**SLOYER, JOHN L., Jr.**  
University of Alabama  
**McGUIDE, JANICE K.** ES73  
**SNYDER, ROBERT S.** ES73  
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**SMALLY, LARRY L.** ES63  
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**KRALL, K. R.** University of Alabama  
**HAGYARD, M. J.** ES52  
**WEST, GEORGE** ES52  
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Computer Sciences Corporation  
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**SMITH, O.E.** ES81  
**AUSTIN, LAMBERT** JSC  
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**SMITH, ORVEL E.** ES81  
**FICHTL, GEORGE H.** ES81  
**VAUGHAN, W. W.** ES81  
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Science and Applications Space Platforms. For publication in *Astronautics and Aeronautics*.

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**DUNING, J.** Indiana University  
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**SPEER, F. A.** TA01  
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**STOKES, JACK W.** EL15  
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**STONE, NOBIE H.** ES53  
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Region Observed with SMM. For publication in *Astrophysical Journal Letters*.

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**TANNER, RAY E.** EE41  
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**TANG, CHUNG-MUH** ES82  
**FICHTL, G.H.**  
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**FICHTL, GEORGE H.** ES82  
**SMITH, STEPHEN R.**

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**THOMPSON, J. R.** SA51  
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**MSFC PAPERS CLEARED FOR PRESENTATION**  
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| <b>TURNER, L. D.</b>   | <b>EP45</b>       |                               |
| <b>HUMPHRIES, W. R.</b>  | <b>EP45</b>       |                               |
| <b>LITTLES, J. W.</b>  | <b>EP45</b>       |                               |
| Effects of the Specular Orbiter Forward Radiators on Typical Spacelab Payload Thermal Environment. For presentation at the 16th AIAA Thermophysics Conference to be held in Palo Alto, CA on June 23-25, 1981.   |                   |                               |
| <b>URBAN, EUGENE W.</b>  | <b>ES63</b>       |                               |
| Optics of Experiments in Spacelab 2. For presentation and publication at the Annual Meeting of Optical Society of America; Journal of the Optical Society of America in Orlando, FL, on October 27-30, 1981.   |                   |                               |
| <b>URBAN, E. W.</b>  | <b>ES63</b>       |                               |
| <b>KATZ, L.</b>  | <b>ES63</b>       |                               |
| <b>WATTS, RAYMOND</b>  |                   |                               |
| Smithsonian Astrophysical Observatory Development and Integration of the Infrared Telescope for Spacelab. For presentation at the 11th Intersociety Conference on Environmental Systems, ASME, to be held in San Francisco, CA, on July 13-15, 1981.               |                   |                               |
| <b>VON TIESENHAUSEN, GEORG</b>   | <b>PS01</b>       |                               |
| Self-Replicating Systems -- A Systems Engineering Approach. For presentation at the AIAA/SSI Fifth Conference on Space Manufacturing to be held in Princeton, NJ, on May 18-21, 1981.  |                   |                               |
| <b>WAITE, J. H.</b>  | <b>ES51</b>       |                               |
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| <b>NAGY, A. F.</b>   |                   |                               |
| <b>ATREYA, S. K.</b>   |                   |                               |
| <b>DONAHUE, T. M.</b>  |                   |                               |
| <b>CRAVENS, T. E.</b>  |                   | <b>University of Michigan</b> |
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| <b>WEISSKOPF, MARTIN C.</b>  | <b>ES62</b>       |                               |
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| <b>WHITAKER, ANN F.</b>  | <b>EH12</b>       |                               |
| Performance of Candidate SEPS Solar Cells as a Function of Low Temperature and Low Intensity Exposure and 1 MeV Electron Irradiation. For presentation at the 15th International Electric Propulsion Conference to be held in Las Vegas, NV, on April 21-23, 1981. |                   |                               |
| <b>YOUNG, L. E.</b>  | <b>EC12</b>       |                               |
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| <b>WHITE, J. B.</b>  | <b>EF12</b>       |                               |
| A Semiconductor Memory System Architecture which Tolerate Radiation Induced Soft Errors. For presentation at IEEE Transactions on Aerospace and Electronic Systems.  |                   |                               |
| <b>WILSON, GREGORY S.</b>  | <b>ES84</b>       |                               |
| Structure and Dynamic of Mesoscale Systems Influencing Severe Thunderstorm Development, AVE/SESAME I. For presentation at the 12th Severe Local Storms Conference 62nd Annual Meeting of AMS to be held in San Antonio, TX, on January 11-15, 1982.                |                   |                               |

**MSFC PAPERS CLEARED FOR PRESENTATION**  
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**WILSON, GREGORY S.** ES84  
Medium-Range, Objective Predictions of  
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12-15, 1981.

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**FACEMIRE, B. R.** ES74  
**LACY, L. L.**

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**WOJTALIK, FRED S.** EE01  
Project HEAO — Revisited. For pre-  
sentation at the Eighth IFAC World  
Congress to be held in Kyoto, Japan on  
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**WU, S. T.** ES01 (UAH)  
**HU, Y. Q.** UAH  
**NAKAGAWA, Y.** UAH  
**TANDBERG-HANSEN** ES01  
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sphere. For presentation at the AGU  
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**WYCKOFF, JAMES** AB43  
Built-Up Roofing Techniques at Marshall  
Space Flight Center, 1976-1980. For  
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**WARMEROD, JOHN D.** ED33  
**VANIMAN, JEROLD L.** ED33  
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External Tank. For presentation at the  
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**WEISSKOPF, M. C.** ES62  
**ELSNER, R. F.** ES62  
**SUTHERLAND, P. G.** McMaster University  
**GRINDLAY, J. R.**

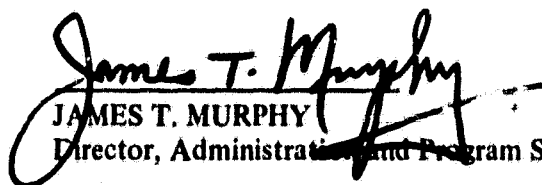
Harvard-Smithsonian Center for Astrophysics  
Search for High Frequency Pulsations  
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## APPROVAL

### FY 1981 SCIENTIFIC AND TECHNICAL REPORTS, ARTICLES, PAPERS, AND PRESENTATIONS

Compiled by Sarah Thacker

The information in this report has been reviewed for technical content. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

  
JAMES T. MURPHY  
Director, Administration and Program Support